Developing a Multimodal AI Framework for Wetlands Mapping with Multi-Sensor Earth Observation Data

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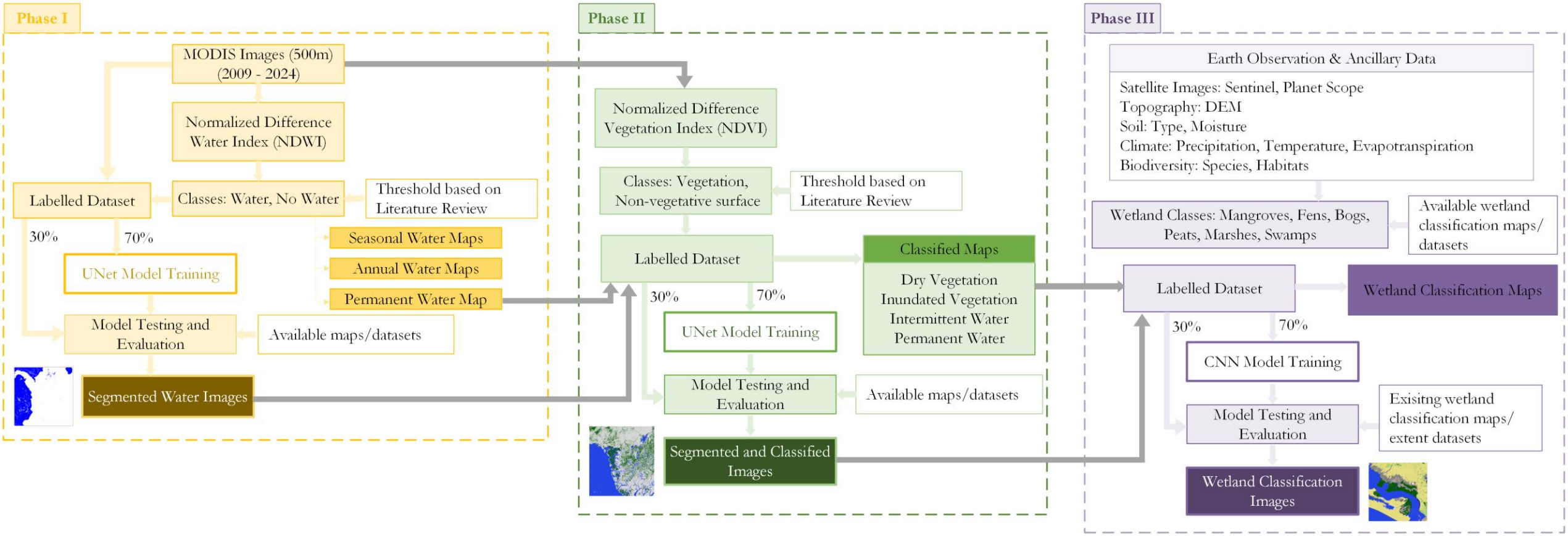
Background and Workflow

- Methane has more than 25 times the warming potential of CO_2 over 100 years
- Wetlands - the largest natural resource of methane. Difficult to map - spatially complex, temporally dynamic, permanent or seasonal, and support diverse vegetation
- Uncertainty in methane flux models: require accurate, high-resolution information on wetlands



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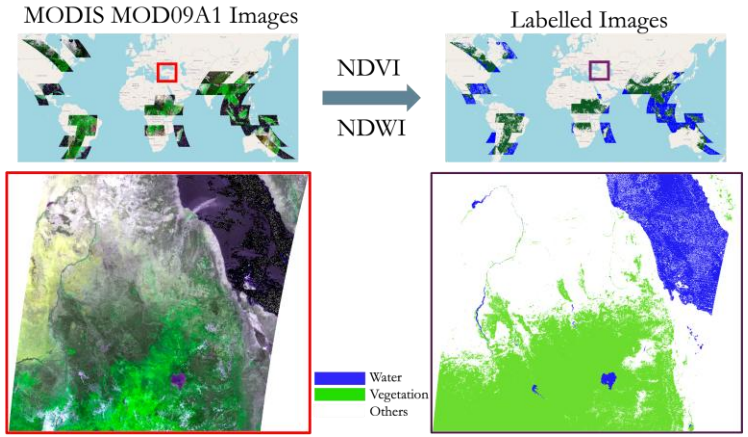
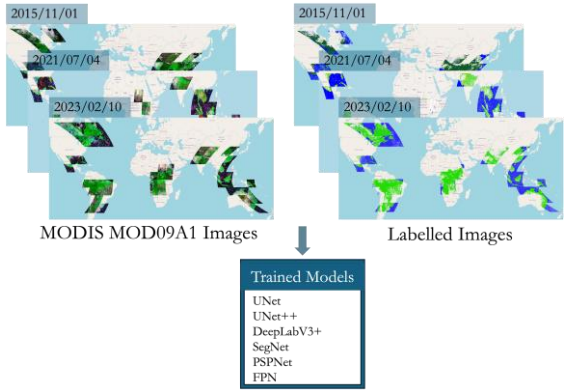
Machine Learning Framework

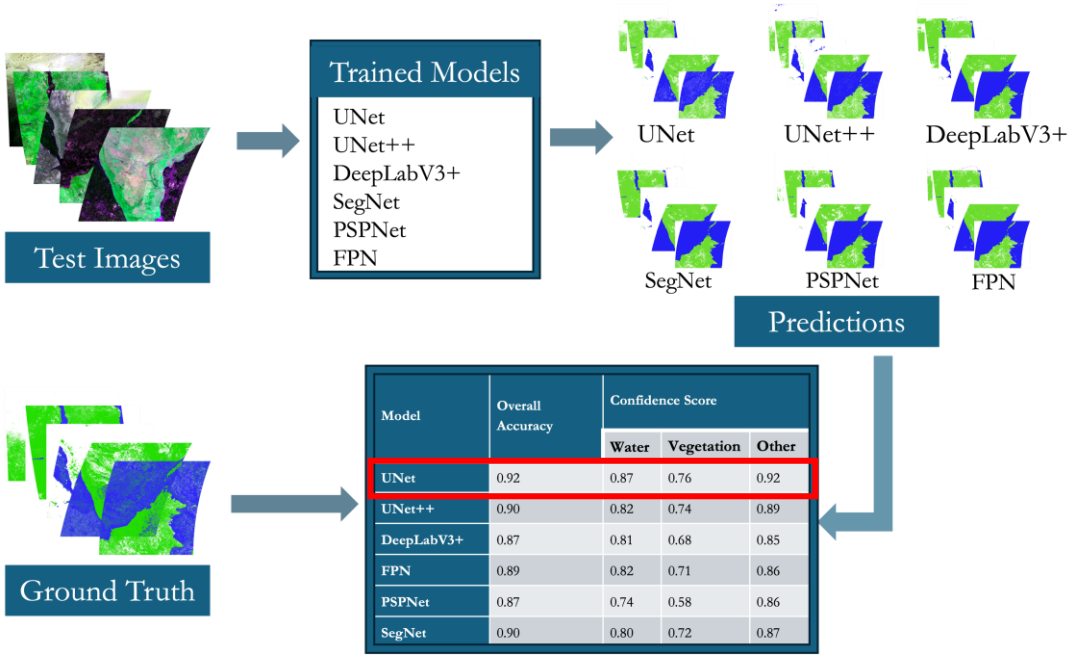


Bands: G, R, NIR, SWIR

Spectral indices (NDVI and NDWI) derived from MODIS MOD09A1 were used to classify pixels as water and vegetation based on histogram thresholding technique.



The labelled data were tiled into 256 x 256 pixels patches, augmented, and was used to train six deep learning models.



Model	Overall Accuracy	Confidence Score		
		Water	Vegetation	Other
UNet	0.92	0.87	0.76	0.92
UNet++	0.90	0.82	0.74	0.89
DeepLabV3+	0.87	0.81	0.68	0.85
FPN	0.89	0.82	0.71	0.86
PSPNet	0.87	0.74	0.58	0.86
SegNet	0.90	0.80	0.72	0.87

UNet model performed best with the highest overall accuracy and highest confidence scores for individual classes.

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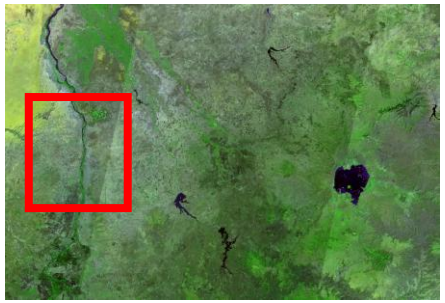
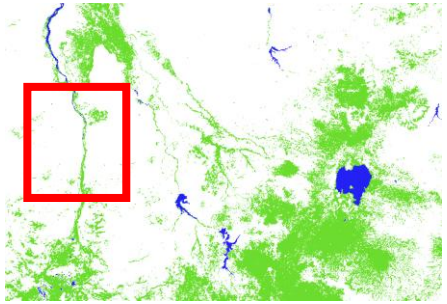
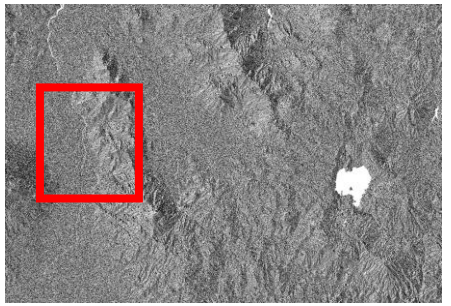
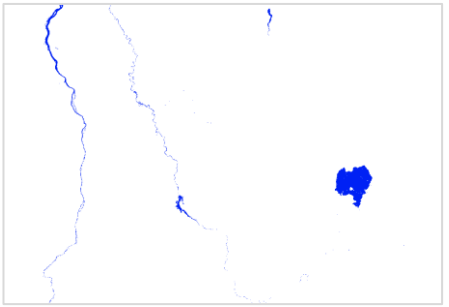
Aspect based Labels Refinement

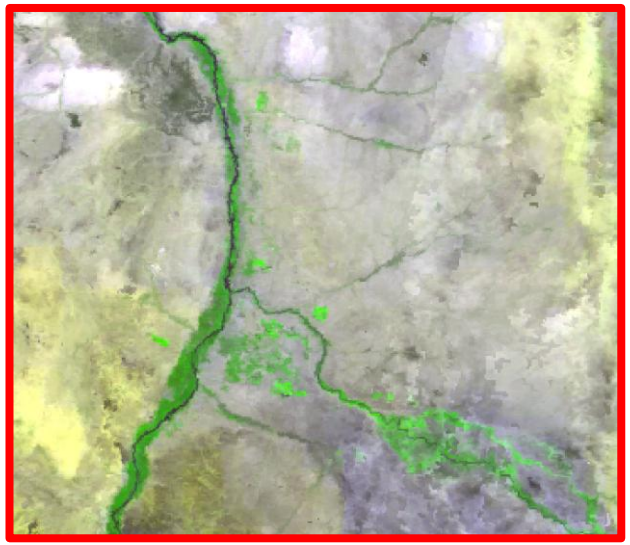




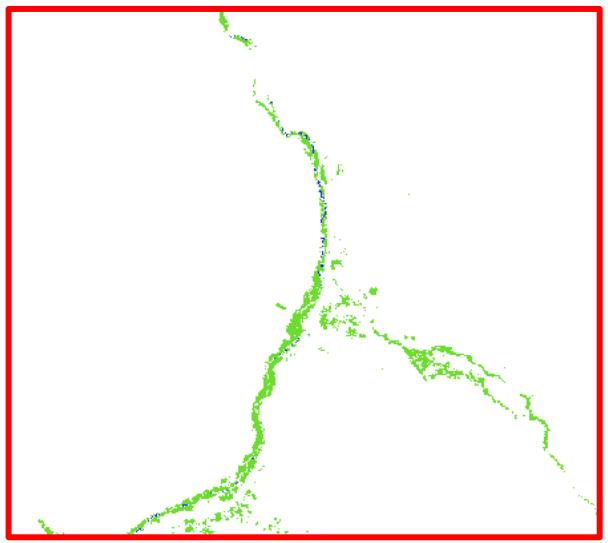


Void mask based on Aspect*

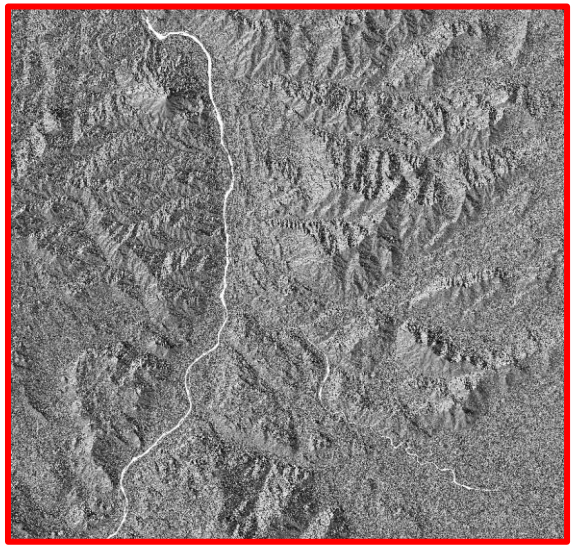




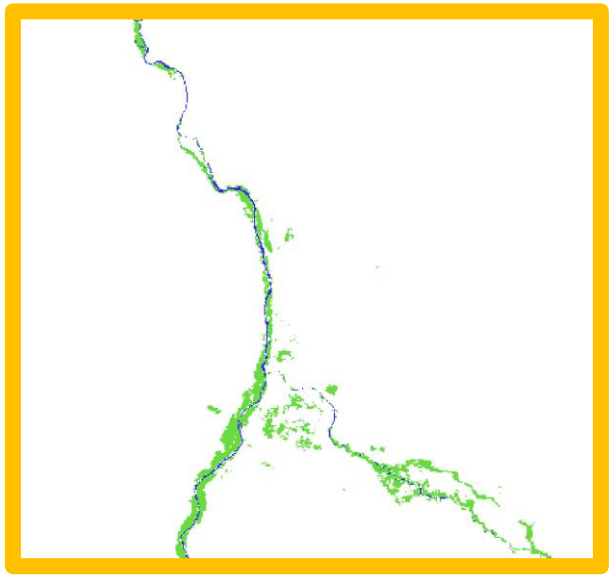
MODIS Image



Classification based on NDVI and NDWI



Aspect based on COP30



Improved labelled image

Despite good overall performance, models struggled to identify thin water channels and smaller water bodies.
Aspect (topographic gradient) derived from Copernicus GLO-30 DEM was used to improved the labelled data

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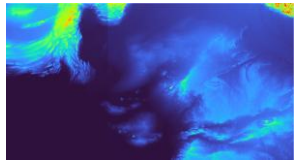
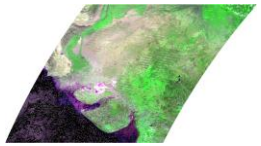
Machine Learning Framework (DEM as additional channel)



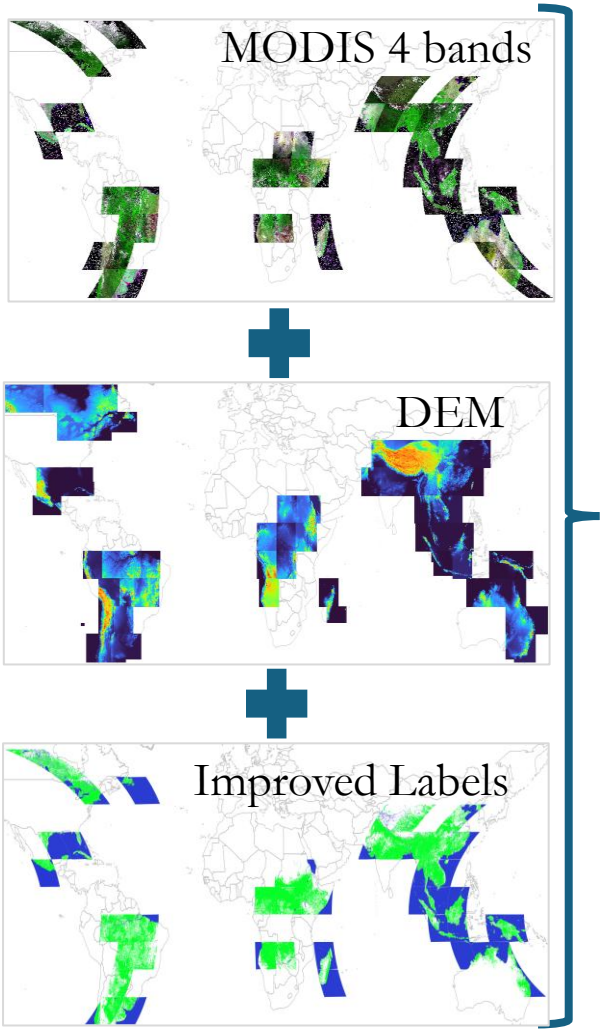
GLO 30m DEM

DEM resampled to 500m



Reference MODIS Image

DEM based on Copernicus GLO-30 was resampled to 500m resolution using averaging technique.



Trained Models

UNet
UNet++
DeepLabV3+
SegNet
PSPNet
FPN

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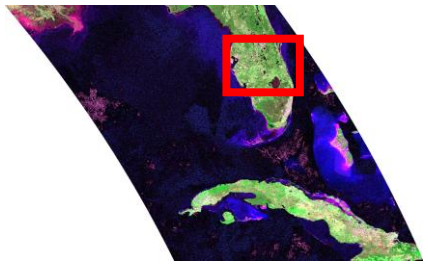
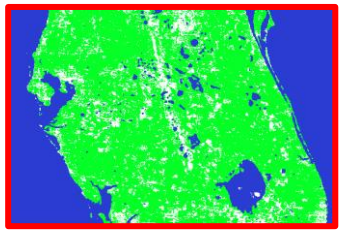


MODIS Image

UNet Prediction



To improve models' prediction capabilities, DEM was included as an additional channel along with the MODIS 4 bands and improved labelled images to train the model

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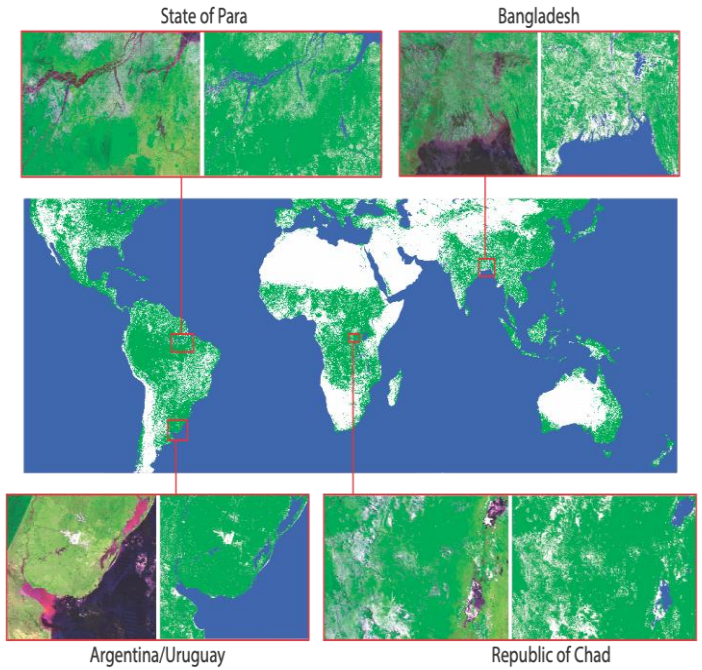
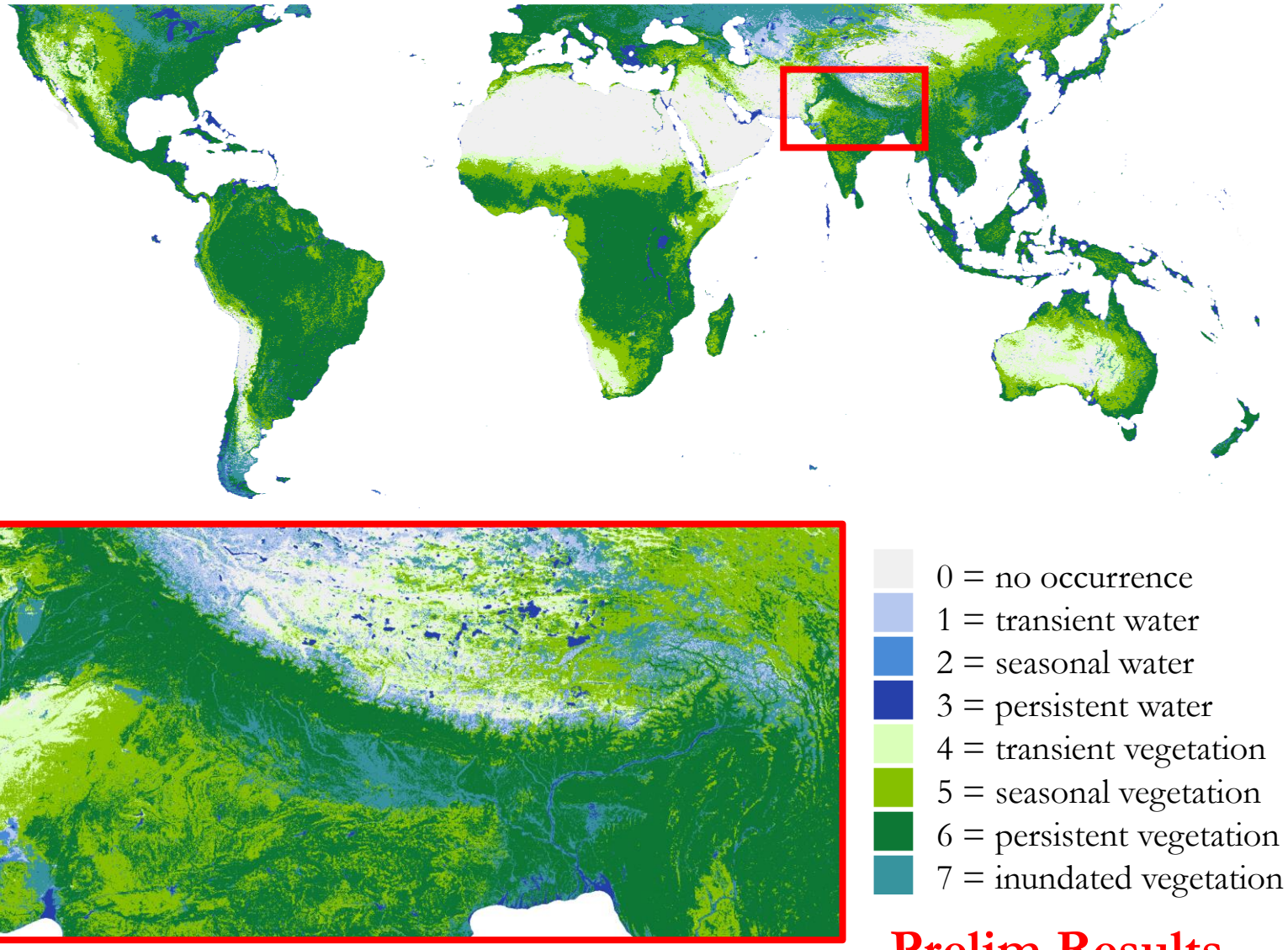
Inference based on Trained UNet





Prelim Results

Time Series Analysis: Water Vegetation Classification 2000-2026

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Next Steps…

- Perform time series analysis to create seasonal, annual, and permanent water maps
- Generate comprehensive wetland maps validated against existing global datasets
- Integrate Sentinel and PlanetScope data for detailed wetland classification
- Use observed wetland extent to drive Digital Twin wetland methane modelling

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